

Title	2. A Theory of Unified Stochastic Process : with an application to light scattering
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approximate equation is obtained with the use of the TC formula.

On the basis of the above equations, the relaxation function, the dielectric function, and the distribution function are derived, and the fluctuation of the dipole moment is also determined. In the white noise limit, McConnel's result is derived in the case of the Gaussian fluctuating force and Van Vleck-Weisskopf, Fröhlich's result is obtained in the case of the two-state-jump fluctuating force. The Debye's result is found in the narrowing limit irrespective of the stochastic processes. Detailed numerical calculations are given and several new aspects are found. Especially for the dielectric function, deviation at high frequencies from the Debye's result is found. This may corresponds to an experiment for polar liquid⁷⁾, though our model is so simple.

2. A Theory of Unified Stochastic Process

— with an application to light scattering —

Kishiko Maruyama

Abstract

In this thesis, two new types of solvable stochastic model are proposed and applied to light scattering phenomena. The theoretical framework for each model is made based on a time-convolution-type equation in the damping theory.

Each model is used to develop a theory of line shape, in which the influence of an environment for a relevant system is idealized so as to be represented with a stochastic process.

Next, each model is used to formulate a light scattering theory, especially focusing on the problem of "Raman versus Luminescence", or on a correlation among incident and scattered photons. For qualitative understanding of a problem like the light scattering, a stochastic approach such as employed here is really powerful.

Recently, according to the development in experimental techniques of generating an ultra-short pulse excitation, various kinds of information upon relaxation phenomena have become obtainable in the real time domain. The models considered here may be of good use for phenomena in the ultra-short time domain.

Two typical stochastic models are frequently used; one is the two-state-jump Markoff process and the other is the Gaussian process. They are the opposite extremes with each other, whereas many real processes assume intermediate character between the two. Thus in part I a model (the first model) which bridges smoothly between these two extremes is introduced as a superposition of N two-state-jump Markoff processes. For a single two-state-jump Markoff process, the "partial cumulants" of higher than the second order vanish identically, so that its power spectrum can be expressed by the first order continued fraction. Because of this simple property, the general structure of the partial cumulants in case of an arbitrary number N can be found. Thus, summing up contributions with the aid of a diagrammatic technique, the power spectrum of the proposed model is determined in a form of the N -step continued fraction. For a clear illustration of this model, a simple example of the random frequency modulation is considered, and then

numerical calculations for its power spectra and its relaxation functions are given.

This model is further adopted to analyze the stationary light scattering; a rigorous expression of the scattering intensity is obtained. This result generalizes that of the stochastic model proposed by Takagahara, Hanamura and Kubo. According to an approach based on a generalized master (time-convolution-type) equation, it is found that the inhomogeneous term plays an essential role, whereas this term plays no important role in existing treatments of the relaxation. This is due to the relaxation mechanism of the light scattering phenomena. Behavior of the light scattering spectrum is systematically investigated by the present theory with the aid of numerical calculations. It is shown how the spectrum changes from the "Raman" to the "Luminescence" under the influence of environment. The multi-peak structure of the luminescence-like spectrum gradually disappears to become a smooth curve when the process is changed from the two-state-jump to the Gaussian.

The transient response for a pulse excitation is also considered with the use of this new model. From the above-mentioned result of the stationary light scattering, the expression for the time-resolved spectrum is readily obtained. This expression can be calculated numerically and a problem of the coherence is discussed.

In part II, a further generalized model (the second model) is proposed. While the usual two-state-jump Markoff process assumes equal weight population for the two states, the newly introduced two-state-jump Markoff process includes an asymmetric population. As a superposition of such constituent processes with asymmetric property,

the new model becomes more flexible than the previous (first) model. In other words, the model is composed of hopping processes among $(N+1)$ -states with the binomial distribution in equilibrium. Namely, the distribution of the n -th state in equilibrium is given by

$$p(n) = {}_N C_n x^{N-n} (1-x)^n, \quad (0 \leq x \leq 1).$$

This model is applied to various problems; the random frequency modulation, the stationary light scattering and the transient light scattering. The spectrum of this model is quite analogous to the one due to the phonon side bands, though the direct comparison must be done carefully.

Our second model may be powerful in treating various systems except the ordinary light scattering, for instance, γ -ray or X-ray scattering in solids. Moreover the formulation developed here may have wide range of applicability to various other phenomena. These remain to be solved in future.

3. Phase Transition Phenomena of Diluted Antiferromagnets in a Magnetic Field and Random-Field Effects

Eriko Sano

A b s t r a c t

Our present work gives an unified interpretation for the phase transition behaviors in three-dimentional dilute Ising antiferromagnets under a uniform